Validation of the Removal Method by Visualization of Liquid Film Behavior

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Diesel engines have been extensively used worldwide as a power source. The urea selective catalytic reduction (SCR) system is used the conversion of nitogen oxide (NOx) in the exhaust gas using urea-water solution (UWS). However, the undesired urea crystallization from the evaporative UWS droplets is concerned as a reason of malfunction. This study was verified the removal methods from the liquid film behaviors. As basic experiment, the changes of liquid film behaviors on different wettability plates were visualized in an acrylic SCR dosing simulator with the multi high-speed cameras. The important factor for prevention method of solid deposits was shown.

Keywords (from 3 to 5 max): Wettability, Urea-SCR system, Solid deposit, Liquid film, Visualization

1. Introduction

The urea SCR system is used the conversion of NOx in the exhaust gas using UWS [1]. However, the undesired urea crystallization from the evaporative UWS droplets is concerned as a reason of malfunction. The assessment of solid deposits coming from liquid film was studied by other reports [2]. However, the prevent methods have not been shown. This study was verified the removal methods from the liquid film behavior. As basic experiment, the changes of liquid film behavior on different wettability plates were visualized in an acrylic SCR dosing simulator with the multi high-speed cameras. The important factor for prevention method of solid deposits was shown.

2. Methods

Figure 1 shows the test up for visualization experiment. The multi High-speed cameras and lights were set by side and top view. The multi synchronized high-speed cameras were controlled using trigger switch connecting both so that liquid film behaviors can visualize in more detail. Table 1 shows the test conditions. Different wettability plates (Non-coating, Hydrophilic and Hydrophobic) were prepared to visualize these behavior changes.

3. Results and Discussion

Figure 2 shows the visualization results of liquid film behavior. The bottom of left figure and right figure were visualized at the same time. Time in figures shows the elapsed time from a starting injection. From the visualization results, the liquid film removed from a plate edge. As a result, it was found that the remaining liquid was kept droplets on the hydrophobic and the non-coating plate. In contrast, the hydrophilic was formed the liquid film. Therefore, the adhesion power of liquid on hydrophobic plate was weakest and the time until the removal was shortest in the kind of three wettability plates. It is considered that the droplet on hydrophobic plate can well use an effect of the gas flow. In this way, the removal efficient with the hydrophobic plate is important in order to prevent the solid deposits.

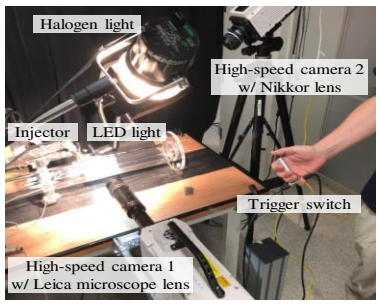

Figure 1: Test set up for visualization experiment.

Table 1: Test conditions

Gas flow velocity [m/s]	9.7
Gas Reynolds number[-]	46574
Injection liquid	Water
Injection mass flow rate [g/s]	0.22
Gas and liquid temperature [˚C]	20

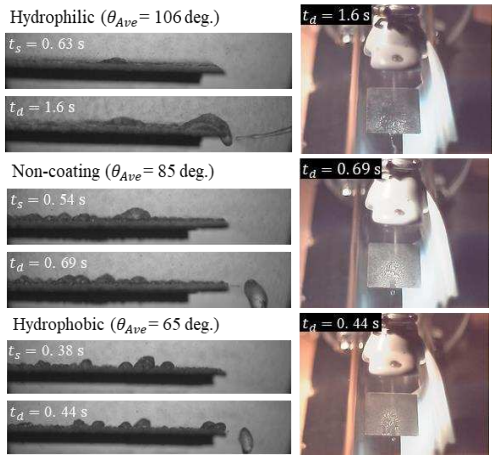

Figure 2: Visualization results of liquid film behavior (Visualization speed: 5000 fps, Exposure time 0.2μs).

4. References

[1] Jaworski, Piotr et al., "SCR Systems for NOx Reduction in Heavy and Light Duty Vehicles", Combustion Engines, 164, 1, 2016, 32-36.

[2] Thomas Lauer, "Preparation of Ammonia from Liquid AdBlue –Modeling Approaches and Future Challenges", Chemie Ingenieur Technik, 90, 6, 2018, 783-794.